



High Resolution Biostratigraphy of CSDP-001 Well, Central Swamp Depobelt, Niger Delta, Nigeria

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Abstract

The studied section of CSDP-001 well in central swamp depobelt of the Niger Delta, Nigeria comprised of 160 ditch-cutting samples. These samples were prepared for high resolution biostratigraphy analysis and interpretation for biozonation and age determination of the Formations penetrated. The analysis is based primarily on data generated from the ditch cuttings. The result yielded eighty-eight (88) calcareous nannofossil species from fourteen (14) genera. The calcareous nannofossils recovered included *Sphenolithus heteromorphus*, *Helicosphaera ampliaperta*, *Reticulofenestra pseudoumbilicus* and *Calcidiscus premacintyreii* among others. These indicate Early to Middle Miocene age. The calcareous nannofossil assemblages recovered indicated that the studied section lies within NN4 which was calibrated into the upper and lower NN4 on the recognition of First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Discoaster deflandrei* at 9170ft. Species abundance and diversity plot provided information on two Maximum Flooding Surfaces at 9230ft (MFS 17.40Ma) and 8540ft (MFS 15.90Ma), and two Sequence Boundary's at 8840ft {SB 16.5 (Bur 5/Lan 1)} and 7640ft {SB 15.5 (Lan 2/Ser 1)}. A biostratigraphic framework was developed for the studied section based on identified bio-events, which provided detailed information on candidate chronostratigraphic surfaces in the studied section for biostratigraphic correlation.

Keywords: Nannofossils, FDO, LAD, Framework, Chronostratigraphic surfaces, Biostratigraphic events, Niger Delta, Nigeria.

Introduction

CSDP-001 well is located in longitude 6° 30' E and latitude 5° 06' N in the central swamp depobelt of the Niger Delta (Fig. 1). The studied section of CSDP-001 well comprised of 160 (6350ft – 11420ft) ditch cuttings sampled at 30ft sampling intervals. The

central swamp depobelt of the Niger Delta is one of the five depositional centers formed as a result of gravity tectonics in response to rate of sediment supply and accommodation space and bounded by regional faults. The central swamp depobelt comprised of the three lithostratigraphic units of the Niger Delta (Doust and Omatsola, 1990) and ranged

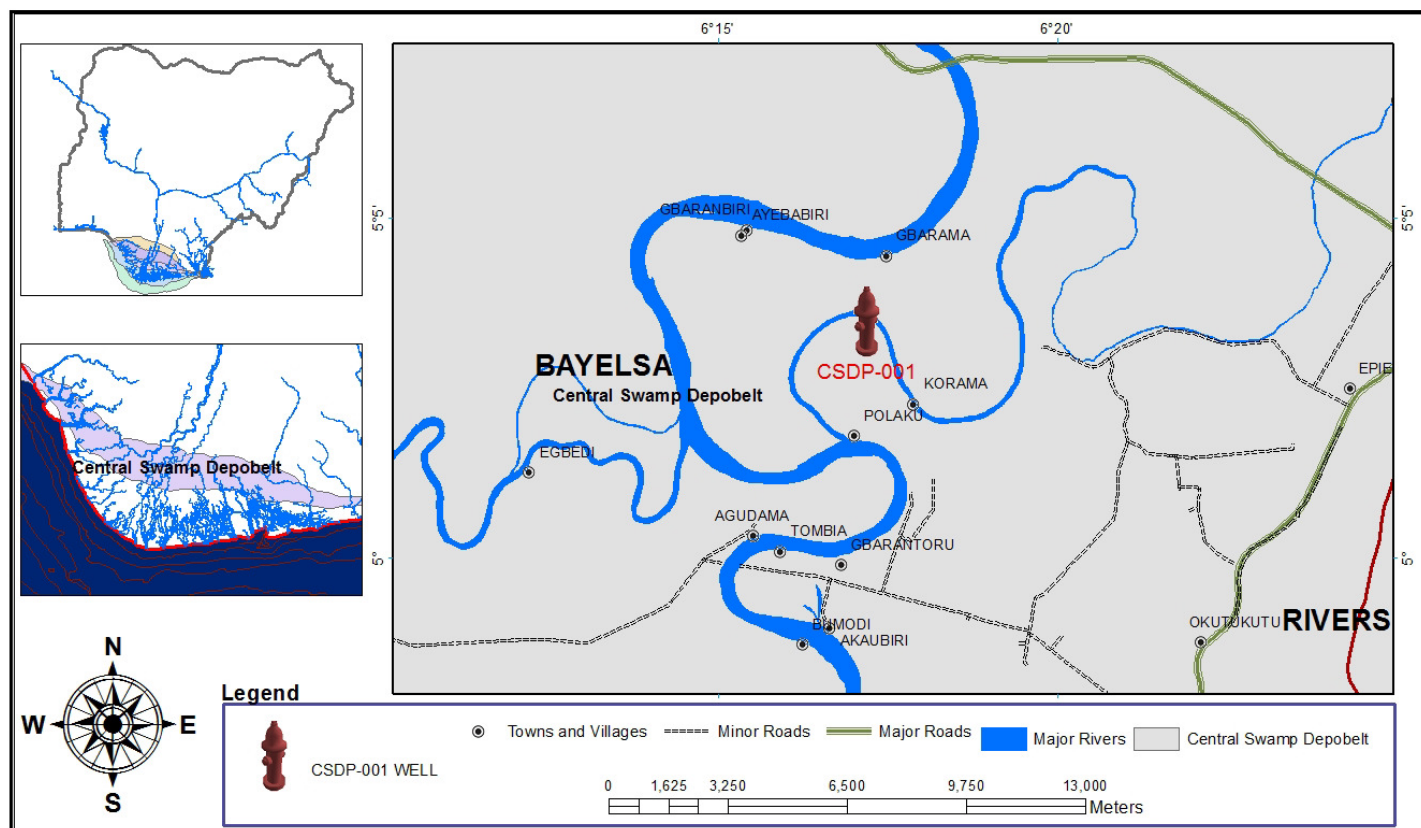


Fig. 1. Map of the study area showing CSDP-001 well.

in age between Eocene to Recent. Like other depobelts in the Niger Delta, it is affected by both syn and post depositional structural deformations that created several structural complexities in the Niger Delta (Kulke, 1995, Evamy et al, 1978, Xiao and Suppe, 1992). These series of deformation both 'syn' and 'post' completely obliterated the original principles of superposition and faunal succession on which the sediments were previously laid at the time of deposition. This research therefore presents the biostratigraphy interpretation of calcareous nannofossils recovered from ditch cuttings of CSDP-001 well in central swamp depobelt of the Niger Delta, Nigeria.

Lithostratigraphy Setting

The lithostratigraphic setting of CSDP-001 well consists of alternating sandstone and shales intercalations with thin streaks of silts which is an indication of deposition within the transitional

environment comprising the lower delta plain, the coastal barrier and the fluvio marine. The sand percentage varies between 30% to 40% at the base and increases to about 60% to 70% towards the top as seen in the gamma ray log signatures and the lithologic log (Fig. 2). The sandstones are very fine to coarse grained, poorly to moderately sorted, non-calcareous to slightly calcareous, loosely consolidated – moderately indurated, smoky white, light to dark grey and brown coloured. The shales are slightly calcareous to calcareous, sub-fissile, fissile to slightly indurated (Table 1).

Materials and Methods

The materials used included flat surfaced smooth crucible, diluted Hydrochloric acid, Hand lens for sample description; Palynological glass slides, Cover slips, ultra violet adhesive (Norland glue), Clean smooth wooden tooth pick, Distilled water with a

dispensing bottle, Hot plate for sample preparation; Transmitting light microscope with a polarizer, Oil immersion for analyses, and Work station, Biostratigraphic analytical tool (StrataBUGs 10.1) for data compilation and processing. The methods involved lithologic sample description; sample preparation; sample analyses and data presentation.

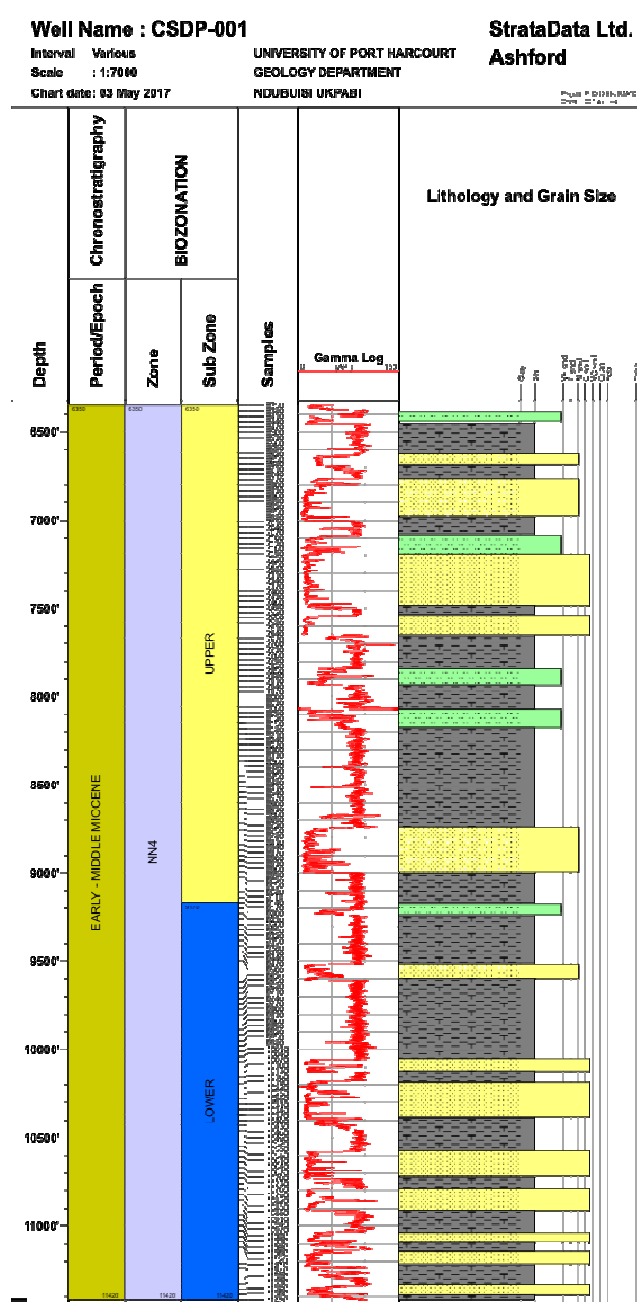


Fig. 2. Gamma ray log signatures and lithologic log of CSDP-001 showing sand and shale intercalations.

Lithological Sample Description

Comprehensive sample description was carried out on the ditch cuttings. The samples were spread out on a flat surface smooth crucible and were examined at 30ft intervals using hand lens to identify the grain sizes and shape, sorting, color, presence of rootlets and other plant remains, mica flakes, pyrites, shell fragments and other physical components of the sample that may be identified through a hand lens. Hydrochloric acid (HCL) was then applied to the sample to determine the presence of calcareous material within the samples and all the identified physical parameters were recorded in a logging sheet which was used to generate a lithologic log.

Calcareous Nannofossil Sample Preparation

Among several calcareous nannofossil sample preparation methods, the simple smear slide method was adopted in this study for its simplicity and higher variability when compared with the spray method (Henderiks and Törner, 2006; Blaj and Henderiks, 2007). This method involved placing few grams of the sample on a prepared glass slide (etched with well name and depth using a labelling sticker). The sample was moistened with one or two drops of distilled water using a dispensing bottle and allowed for few minutes to soak. The moistened sample was smeared gently but evenly across the glass slide and the sand grains carefully removed. The glass slide was placed on a hot plate with gentle heat to dry. One or two drops of ultra violet adhesive (Norland adhesive) was dropped on the rectangular glass cover slip; this was used to cover the glass slide to avoid contamination. The prepared slide was allowed to dry.

Calcareous Nannofossil Sample Analyses

The calcareous nannofossils slides generated were studied under a transmitting light microscope with a polarized light using 100x magnification microscope objective lens with the aid of oil immersion. The sample analyses involved the standard scanning of 25

traverses on the short axis or 10 traverses on the long axis of the prepared calcareous nannofossil slides. During this process, the taxa were counted and recorded on a simple tick sheet to generate the total assemblages of calcareous nannofossil recovered from the sample preparations while the scanning was going on. The presence/absence counting technique was adopted for complete fields of view coverage of the calcareous nannofossil slide.

Calcareous Nannofossil Data Presentation

The taxa count documented on a simple tick sheet was computed in micro-soft excel (spread sheet) and called up into the biostratigraphy analytical software (STRATABUGS 10.1) from where data trawling, and all other deductions based on observable trending patterns of the data were made.

Results

Detailed description of major lithological units penetrated in CSDP-001 presented in (Table 1) is as follows:

Table 1. Lithostratigraphic description of CSDP-001 well.

DEPTH (FT)	LITHOLOGY	LITHOSTRATIGRAPHY
6350 - 7640	Sand with shale streaks and minor silt bands	AGEBADA FORMATION
7640 - 8720	Shale with minor silt bands	
8720 - 10070	Shale with sand streaks and minor silt band	
10070 - 11420	Shale/sand intercalation	

Interval: 6350ft – 7640ft

Lithological unit: Sand with shale streaks and minor silt bands

This lithologic unit consists predominantly of sand with shale streaks and minor silt bands. The sand forms the predominant constituent within the interval. The sand is very fine to medium grained, slightly indurated, non-ferruginized, moderately to poorly sorted; the grains are angular, sub-angular to sub-rounded, non-calcareous, rare occurrence of mica

flakes. Few shale streaks occurred within this interval. The Shale is light to dark grey in colour, sub-fissile to fissile, rare occurrence of mica flakes and non-calcareous. Minor silt bands' occurring in this interval is light grey, slightly indurated and non-calcareous.

Interval: 7640ft – 8720ft

Lithological unit: Shale with minor silt bands

This lithologic unit consists predominantly of shale with minor silt bands. The shale form the predominant constituent within the interval. The Shale is dark grey to black in colour, fissile, with rare occurrence of mica flakes and presence of carbonaceous materials. Minor silt bands occurred in this interval. The silt is dark grey to brownish in colour, angular to sub-angular, moderately sorted, friable, non-calcareous with the presence of few glauconite.

Interval: 8720ft – 10070ft

Lithological unit: Shale with sand streaks and minor silt band

This lithologic unit consists predominantly of shale with sand streaks and minor silt bands. The shale forms the predominant constituent within the interval. The Shale is dark grey to black in colour, fissile, with rare occurrence of mica flakes and presence of carbonaceous materials. The sand is very fine to medium grained, moderately indurated, non-ferruginized, moderately to poorly sorted, the grains are sub-angular, sub-rounded to rounded, non-calcareous, presence of few mica flakes. The minor silt bands occurring in this interval is dark grey to brown, slightly indurated and non-calcareous.

Nannofossil recoveries in the studied section of CSDP-001 well were very rich and diverse. The range of occurrence of the different taxa recovered was populated in the stataBugs chart (Fig. 3), and presented in Plate 1, it showed top occurrences of *Helicosphaera ampliaperta* and base occurrence of *Sphenolithus heteromorphus*, as well as occurrences of mostly Early to Middle Miocene taxa such as

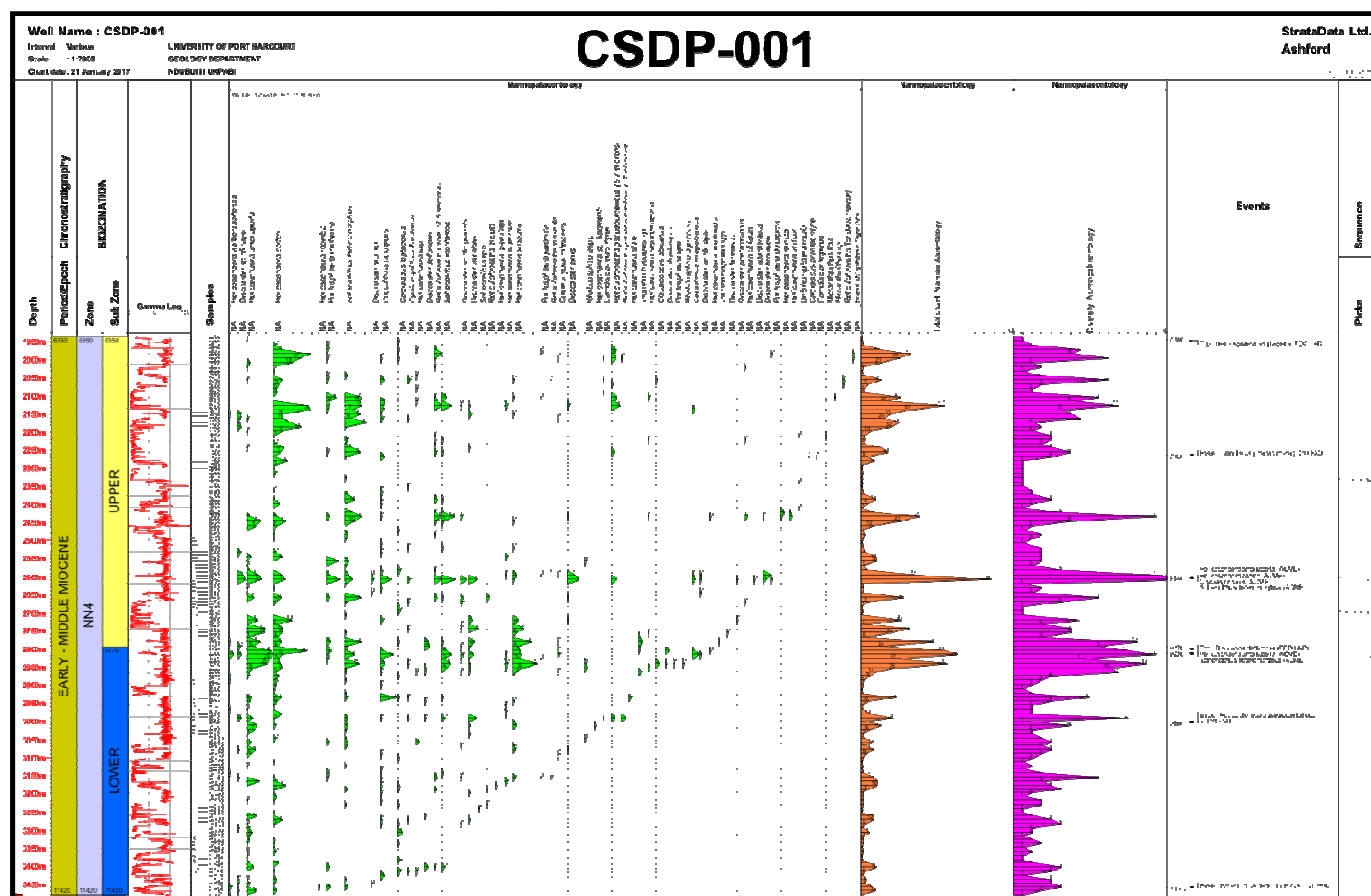


Fig. 3. Biostratigraphic chart of CSDP-001 well.

Helicosphaera walbersdorfensis, *Discoaster* sp., *Helicosphaera rhomba*, *Helicosphaera carteri*, *Pontosphaera multipora*, *Discoaster moorei*, *Coccolithus pelagicus*, *Calcidiscus leptoporus*, *Cyclicargolithus floridanus*, *Discoaster deflandrei*, *Reticulofenestra haqii*, *Sphenolithus moriformis*, *Discoaster variabilis*, *Reticulofenestra minuta*, *Helicosphaera granulata*, *Helicosphaera euphratis*, *Helicosphaera scissura*, *Pontosphaera japonica*, *Reticulofenestra minutula*, *Coronocylus nitescens*, *Discoaster exilis*, *Rhabdosphaera* spp., *Calcidiscus macintyreii*, *Helicosphaera stalis*, *Triquetrorhabdulus* sp., *Helicosphaera mediterranea*, *Clausicoccus abruptus*, *Rhabdosphaera procera*, *Coccolithus miopelagicus*, *Helicosphaera intermedia*, *Transversopontis* spp., *Discoaster formosus*,

Discoaster pentaradiatus, *Helicosphaera obliqua*, *Discoaster adamanteus*, *Discoaster brouweri*, *Pontosphaera discopora*, *Helicosphaera vedderi*, *Umbilicosphaera rotula*, *Calcidiscus tropicus*, *Micrantholithus flos*, *Reticulofenestra floridana*, and *Braarudosphaera bigelowii*.

Discussion

Calcareous nannofossils recovery within the studied section of CSDP-001 well is abundant and diverse with mostly Early to Middle Miocene taxa. Two major species identified which are *Helicosphaera ampliaperta* and *Sphenolithus heteromorphus* formed the bases for biozonation following Martini, 1971 Biozonation scheme. The corresponding Top occurrence (FDO/LAD) of *Helicosphaera ampliaperta* in the studied section was used here to

DEPTH (Ft)	BIOEVENTS (This work)	AGE (Ma) Haq, et al., 1988	NN ZONE Martini, 1971	SUBZONE	INFERRED RELATIVE AGES
6380	Top Sample Analysed FDO/LAD: <i>Helicosphaera ampliaperter</i>				
7430	LDO/FAD: <i>Calcidiscus premacintyre</i>				
7640	SB 15.5 (Lan 2/Ser 1)	15.50			
8540	MFS: 15.90Ma [<i>Helicosphaera ampliaperter</i> (ACME) <i>Helicosphaera cartari</i> (ACME) <i>Helicosphaera moriformis</i> (ACME) <i>Discoaster exilis</i> (ACME) <i>Sphenolithus heteromorphus</i> (ACME)]	15.90		UPPER	MIDDLE MIOCENE
8840	SB 16.5 (Bur 5/Lan 1)	16.50	NN4		
9170	FDO/LAD: <i>Discoaster deflandrei</i>				
9230	MFS: 17.40Ma [<i>Helicosphaera ampliaperter</i> (ACME) <i>Sphenolithus heteromorphus</i> (ACME)]	17.40		LOWER	EARLY MIOCENE
9860	LDO/FAD: <i>Reticulofenestra pseudoumbilicus</i>				
11360	LDO/FAD: <i>Sphenolithus heteromorphus</i> Base Sample Analysed				

Fig. 4. Biostratigraphic framework of CSDP-001 Well.

mark top of NN4. The Base continuous occurrence of *Sphenolithus heteromorphus* also suggest NN4 as FAD/LDO of *Sphenolithus heteromorphus* mark the base of NN4 which was not met in the studied section. Top of NN4 zone is marked in the well at 6380ft. The top and base of the studied section is within NN4 zone which was calibrated into Upper and Lower NN4 zone based on FDO/LAD of *Discoaster deflandrei* at 9170ft. The interval is characterized by a well-developed nannofossil recovery with several biostratigraphic events such as explosive events (ACME) of some species leading to maximum abundance and diversity of taxa which corresponded to Maximum Flooding Surfaces and abrupt drop to

complete absence of taxa which corresponded to Sequence Boundary. Two major abundance and diversity peaks and their corresponding ACME events were identified and was correlated to Haq et al, 1988 to correspond to MFS 17.40Ma at 9230ft and MFS 15.90Ma at 8540ft. MFS 17.40Ma was marked with the first abundance and diversity peak and first ACME event of *Helicosphaera ampliaperter* and *Sphenolithus heteromorphus* within NN4 while MFS 15.90Ma was marked with the second abundance and diversity peak and ACME event of *Helicosphaera cartari*, *Helicosphaera moriformis*, *Discoaster exilis* and second ACME event of *Helicosphaera ampliaperter* and *Sphenolithus heteromorphus* within NN4

Explanation to Plate 1

Plate	Species	Depth and well of occurrence
1	<i>Sphenolithus heteromorphus</i>	6710 ft, CSDP-001 well
2	<i>Helicosphaera ampliaperta</i>	6380 ft, CSDP-001 well
3	<i>Discoaster exilis</i>	7070 ft, CSDP-001 well
4	<i>Helicosphaera scissura</i>	6740 ft, CSDP-001 well
5	<i>Calcidiscus macintyre</i>	6590 ft, CSDP-001 well
6	<i>Sphenolithus heteromorphus</i>	7040 ft, CSDP-001 well
7	<i>Micrantholithus flos</i>	7280 ft, CSDP-001 well
8	<i>Helicosphaera ampliaperta</i>	6380 ft, CSDP-001 well
9	<i>Coccolithus pelagicus</i>	6590 ft, CSDP-001 well
10	<i>Discoaster variabilis</i>	7070 ft, CSDP-001 well
11	<i>Helicosphaera mediterranea</i>	7010 ft, CSDP-001 well
12	<i>Clausicoccus obruptus</i>	9320 ft, CSDP-001 well
13	<i>Helicosphaera ampliaperta</i>	6650 ft, CSDP-001 well
14	<i>Cyclicargolithus floridanus</i>	6740 ft, CSDP-001 well
15	<i>Coronocyclus nitescens</i>	6590 ft, CSDP-001 well
16	<i>Clausicoccus fenestratus</i>	6500 ft, CSDP-001 well
17	<i>Helicosphaera scissura</i>	7010 ft, CSDP-001 well
18	<i>Cyclicargolithus floridanus</i>	7160 ft, CSDP-001 well
19	<i>Helicosphaera ampliaperta</i>	7250 ft, CSDP-001 well
20	<i>Sphenolithus heteromorphus</i>	7100 ft, CSDP-001 well

(Hardenbol et al, 1998). Two Sequence Boundary {SB 16.5 (Bur 5/Lan 1), SB 15.5 (Lan 2/Ser 1)} was identified in the studied section which corresponded to abrupt drop in abundance and diversity of taxa for SB 16.5 (Bur 5/Lan 1) at 8840ft and complete absence of taxa for SB 15.5 (Lan 2/Ser 1) at 7640ft. The studied section of the well corresponded to Early to Middle Miocene in age and ranged between 17.40Ma at the base to 15.90Ma at the top.

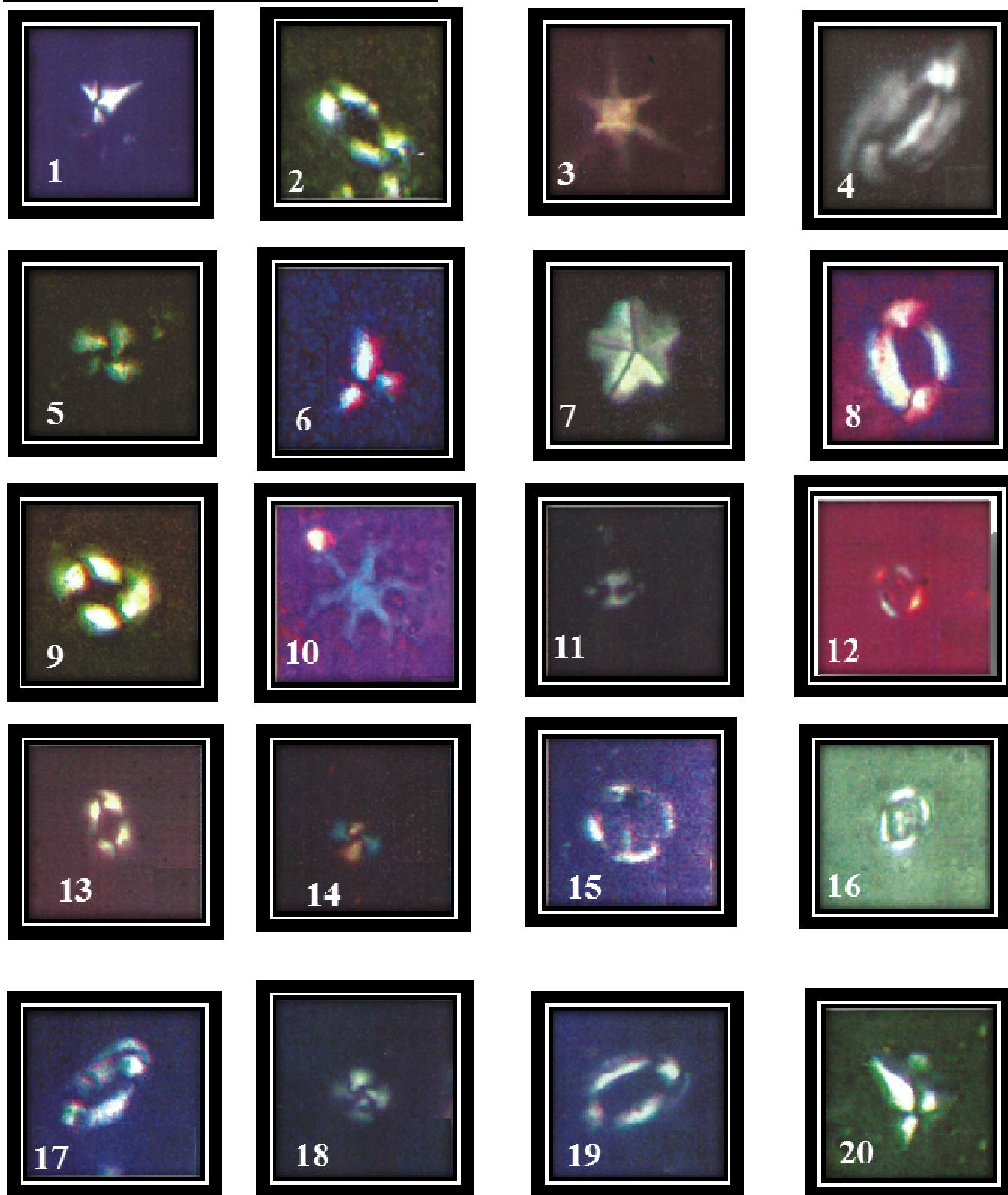
Conclusion

The studied section of CSDP-001 well comprised top to base occurrence of *Helicosphaera ampliaperta*, Last Downhole Occurrence/First Appearance Datum LDO/FAD of *Reticulofenestra pseudoumbilicus* and *Calcidiscus premacintyre* which are markers

indicative of NN4 zone of Martini (1971) biozonation scheme. The zone was further calibrated into Upper and Lower NN4 zone based on the First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Discoaster deflandrei* at 9170ft. CSDP-001 well penetrated two Maximum Flooding Surfaces at 9230ft (MFS 17.40Ma) and 8540ft (MFS 15.90Ma), it also penetrated two Sequence Boundary's at 8840ft {SB 16.5 (Bur 5/Lan 1)} and 7640ft {SB 15.5 (Lan 2/Ser 1)}.

The biostratigraphic framework of the studied section in CSDP-001 well based on identified biostratigraphic events, candidate chronostratigraphic surfaces and geologic ages recognized in the studied section is shown in Fig. 4.

Plate 1. Photographs of some nannofossils.



Note*: All photomicrographs in Plate 1 were taken at 1000X magnification

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